NOTES ON THE SYNTHETIC RESIN HYRAX

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For many years Canada balsam has been the standard mounting medium for most mineralogical and petrographical material, because of its stability, clarity, and ease of preparation, and because its index of refraction is convenient for many purposes. There are certain purposes, however, for which a resin of higher index could be employed to advantage in work of this kind. The purpose of this paper is to discuss the properties of one such resin, hyrax; the methods of preparing mounts with the resin; and several of its possible applications in mineralogy and petrography.

The author is indebted to the Department of Mineralogy of Columbia University for furnishing the facilities and most of the material for the work here described. He also wishes to express his gratitude to Dr. Paul F. Kerr, of Columbia, for many suggestions and much constructive criticism, and for a critical reading of the manuscript. Mr. Paul H. Bird, of the same institution, has also made a number of helpful suggestions, based on his experience in making thin sections.

PROPERTIES OF HYRAX

Hyrax is the result of a search initiated by G. D. Hanna (1) for a satisfactory high-index mounting medium for diatoms. It is a synthetic resin, a stable derivative of naphthalene soluble in toluol, xylol, benzol, and a number of other organic solvents, but not in alcohol or in water. When pure it is a transparent, brittle, amorphous solid, straw yellow in bulk but almost colorless in thin films. It is permeable to the blue and violet rays, important in photography (2). Slides kept by Hanna (2) from 1926 to 1930 showed no decomposition or alteration, although there was a slight darkening, comparable to that observed in old balsam slides, in hyrax slides left exposed to light.

Hyrax is obtainable from the manufacturers[1] either in solid form or dissolved in toluol. The dissolved resin has an index of refraction of about 1.65, but the index increases as the solvent is evaporated and reaches a maximum with complete removal of the solvent.

[1] Penn and Ruedrich, Box 26, Associated, Cal. Eastern agent: Eimer and Amend, *New York City,* N.Y.

There has been considerable disagreement as to the exact value of this upper limit. The various values reported range from 1.70 to 1.825.

For petrographic and mineralogic work, it is essential that the mounting medium used be of known, constant index of refraction; for the identification of imbedded minerals is commonly based partly on their indices referred to the index of the medium. For this reason the author felt it necessary to make a careful redetermination of the index of pure hyrax, with due regard to possible sources of error.

The variations in the reported results may be due, in different cases, to any one of the following causes:

(1) Instability of the resin, with resultant inconstancy of index.
(2) Failure to evaporate the solvent completely from dissolved hyrax.
(3) Use of different wave-lengths of light by different observers.
(4) Unreliability of the method of determination used.
(5) Mechanical error.

The resin has not been proved to be perfectly stable, but according to Hanna (1) no indication to the contrary has appeared. The slides of mineral fragments mentioned below confirm this statement. Failure to evaporate the solvent completely from dissolved hyrax was avoided by the writer by using the pure, solid resin to mold the prism required for the determination. Certain of the higher values reported for the index of refraction of hyrax were obtained in violet or ultra-violet light. Since most microscopic and photomicrographic work is done in ordinary light, the present determination was made in sodium light, as giving a value approximating that obtained by the method of central illumination in ordinary light.

The prism method of determination was used. In order to reduce mechanical error to a minimum, an average of five separate determinations was taken, giving a value of $n = 1.7135$. As a rough check on the accuracy of the determination and the constancy of the material, the author has also prepared numerous slides of minerals ranging in their indices of refraction from 1.68 to 1.76.

Preparation of Mounts with Hyrax

If dissolved hyrax is used, it should be further diluted with one part of toluol to three parts of hyrax, by volume, otherwise bubbles are apt to form during cooking. The time necessary to remove

the solvent varies with the temperature at which it is evaporated and with the depth of the resin in the cooking vessel. Thin films cooked on slide glasses require one hour at 100° Centigrade.

The preparation of thin sections has been described by H. G. Fisk (4). If this procedure is followed, the long period of cooking mentioned by him may be avoided by obtaining solid hyrax.

Hyrax has a higher surface tension than has balsam; hence bubbles are somewhat more difficult to avoid in preparing slides with the former resin. This is particularly true in making slides of mineral grains (or fragments), for it is not possible to squeeze all bubbles from such a slide by gentle pressure on the cover glass while the slide is cooling. The writer has found that a few bubbles must be expected in most slides of this type. If the method described below is followed carefully, these will be not only few in number but also extremely minute, unattached to the mineral grains, and in no way detrimental to the usefulness of the slide.

In making mounts of mineral fragments with Canada balsam the practice is first to cook the resin on the slide and then to place the fragments in the resin. If this procedure is followed with hyrax many of the fragments remain on the surface of the resin, and bubbles form. In making mounts with hyrax, therefore, the fragments should be scattered on the slide glass first, and the resin, previously diluted as described above, should then be poured over the fragments in sufficient amount to form a patch somewhat larger than the cover glass to be used. The slide should next be placed on the heating unit, cooked for one hour at 100° Centigrade, and then removed. At this point the slide should be free from bubbles. Stirring the fragments must not be resorted to at any stage, or bubbles will appear which subsequent cooking will not eliminate; moreover, gentle pressure on the cover glass while the slide is cooling will secure a satisfactory distribution of the grains. The only bubbles which cannot be eliminated from the mounts are those which usually appear when the cover glass is placed on the slide. These may be reduced to a minimum by resting one edge of the cover glass on the slide, just within the boundary of the patch of hyrax, and allowing the cover glass to drop slowly and evenly. During this operation the heating unit should be kept at a temperature of 120° Centigrade.

Applications of Hyrax

In general, the high index of refraction of hyrax makes it useful:

(1) For increasing the relief of minerals which have indices of refraction close to that of balsam.
(2) For decreasing the relief of minerals which have indices of refraction too much above that of balsam.
(3) For facilitating the identification of certain minerals.

The cleavage, form, and fracture of grains of minerals whose indices lie close to that of balsam are not clearly visible, but merely suggested by the outlines of the grains. In hyrax these features are clearly distinguishable; and as they often give clues to the identities of the minerals, or to the processes which the grains have undergone, hyrax can be used to advantage for permanent mounts of grains of these minerals (cf. Pl. I, Figs. 1 and 2).

Since most sandstones and sands are composed largely of quartz grains, in any study of the grains composing such rocks, with the purpose of determining, from the shapes of the grains, the agents responsible for their transportation and deposition, it is better to mount the grains in hyrax, in which not only the outline but also every detail of the shape of each quartz grain is revealed.

In the photomicrography of mineral grains the difference between the refractive indices of mineral and mounting medium (i.e., the relief) has an important bearing on the results obtained. If the relief is too low, the grains appear on the plate as mere outlines. If the relief is too high, those portions of the surfaces of the grains which are not parallel to the plane of the stage of the microscope become, due to internal total reflection, too deeply shadowed, so that the peripheries of the grains appear in the photomicrograph only as dark rings.

The photomicrographs of mineral grains reproduced in Plate I illustrate the results obtained with varying degrees of relief. The index of refraction of quartz is very near that of balsam; hence the shapes of quartz fragments mounted in balsam (Fig. 1) are not clearly visible. Increasing the relief by mounting the fragments in hyrax (Fig. 2) gave greater visibility. On the other hand, the index of refraction of corundum is so much higher than the index of balsam that the peripheries of fragments of the mineral mounted in balsam (Fig. 3) are dark, while in some cases entire grains appear deeply shadowed. Fragments of the same mineral mounted in hyrax (Fig. 4) have relief sufficient to bring out the details of the shapes of the fragments, but the dark borders are reduced in width. Grains of monazite in balsam (Fig. 5) show a similar contrast to grains of the same mineral mounted in hyrax (Fig. 6).

PLATE I

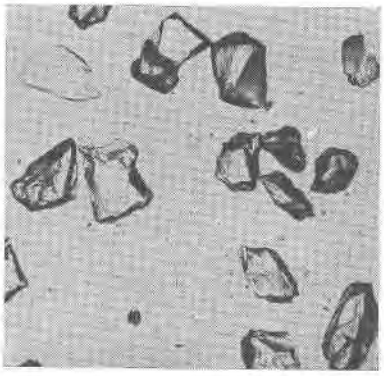

FIG. 1. Quartz fragments in balsam. Average relief = .009.

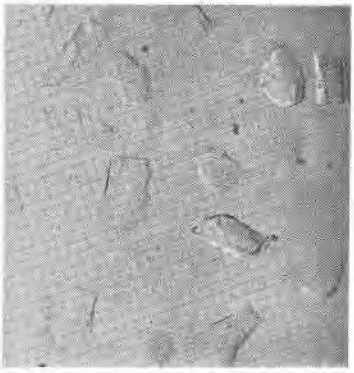

FIG. 2. Quartz fragments in hyrax. Average relief = .165.

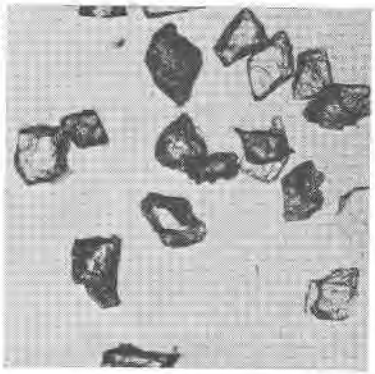

FIG. 3. Corundum fragments in balsam. Average relief = .225.

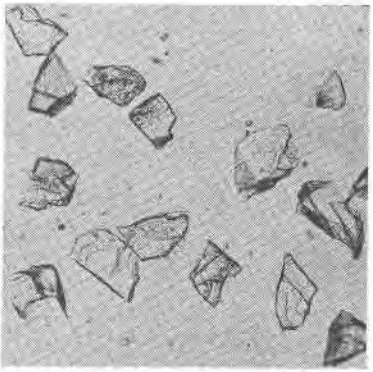

FIG. 4. Corundum fragments in hyrax. Average relief = .051.

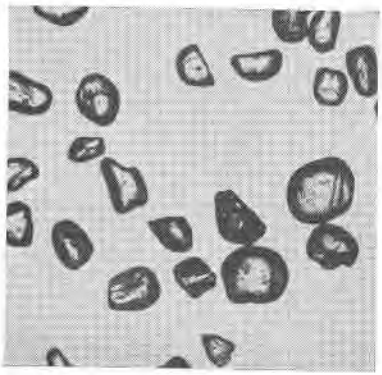

FIG. 5. Monazite sand in balsam. Average relief = .280.

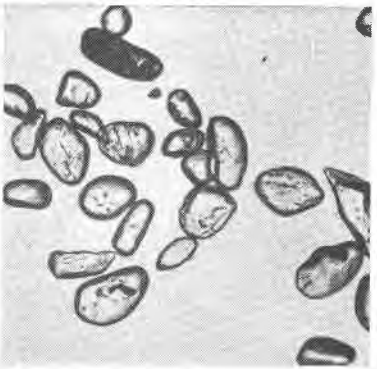

FIG. 6. Monazite sand in hyrax. Average relief = .112.

A series of photomicrographs taken for the purpose of determining the proper relief shows that good results are obtained when relief lies between .040 and .140. In general, too much relief is better than too little. Definition appears to be best when relief lies between .040 and .070. In the case of a given mineral, its refractive index will indicate whether balsam or hyrax is to be preferred as a mounting material.

The identification of the various members of a mineral assemblage is aided if it is possible to split the assemblage into two groups, relative to the index of refraction of the medium in which the minerals are mounted. An example of this is the convenient position of the index of balsam among the indices of the feldspars. If the indices of all, or nearly all, the members of an assemblage lie above (or lie below) the index of the imbedding medium, the indices of the members are of little value, except in so far as relief can be estimated, which is at best a doubtful procedure. For a given assemblage, therefore, the material which divides the assemblage most nearly into two equal groups is to be preferred as a mounting medium.

In view of this fact, it appears that hyrax should be useful as a permanent mounting medium for a number of different heavy mineral assemblages. The following list of minerals most commonly occurring in heavy mineral residues is adapted from Milner (5). The two indices given for each (except leucoxene and fluorite) represent the minimum and maximum indices, respectively, which the species may show (6 and 7) and therefore represent the limits of the range of indices for the particular species. The minerals are here arranged in two groups, relative to the index of hyrax; hence certain of the species appear in both parts of the table. In each part the minerals are listed in order of increasing minimum index of refraction.

Of the 31 mineral species given in the table, only 3 (fluorite, aragonite, and biotite) may have indices of refraction below that of balsam (n = about 1.54), while 19 may have one or more indices below the index of hyrax and 17 may have one or more indices above the index of hyrax. Inclusion of the less common heavy minerals would not change the proportions materially; hence the index of hyrax, which enables division of the group into two nearly equal parts, should make the resin more suitable than balsam as a permanent mountant for such residues.

In a thin section of a given rock, the visibility of the microstructures of the rock, and of the internal structures and mutual relations of the component mineral grains is to some extent dependent on the relief between the minerals of the rock and the material in which the section is mounted. Thus, it sometimes happens that features of this kind which are obscure in sections mounted in balsam are more clearly defined in sections mounted in hyrax.

TABLE I.—DISTRIBUTION OF MINERALS WITH REFERENCE TO HYRAX AS THE MOUNTING MEDIUM

1 or >1 index<n hyrax		1 or >1 index>n hyrax	
Mineral	Indices	Mineral	Indices
Fluorite	1.434	Smithsonite	1.621–1.849
Aragonite	1.530–1.685	Siderite	1.633–1.875
Biotite	1.535–1.690	Augite	1.712–1.733
Tremolite	1.599–1.624	Spinel	1.713–1.726
Tourmaline	1.620–1.690	Cyanite	1.713–1.729
Glaucophane	1.621–1.639	Epidote	1.729–1.780
Smithsonite	1.621–1.849	Grossularite	1.730–1.735
Andalusite	1.629–1.647	Staurolite	1.736–1.746
Apatite	1.629–1.648	Corundum	1.760–1.769
Siderite	1.633–1.875	Monazite	1.800–1.849
Barite	1.636–1.648	Titanite	1.888–2.008
Enstatite	1.656–1.671	Zircon	1.927–1.982
Sillimanite	1.657–1.684	Cassiterite	1.996–2.093
Hornblende	1.658–1.701	Chromite	2.069–2.160
Hypersthene	1.692–1.705	Octahedrite	2.487–2.564
Zoisite	1.696–1.706	Rutile	2.567–2.981
Augite	1.712–1.733	Leucoxene	high
Spinel	1.713–1.726		
Cyanite	1.713–1.729		

In such cases the latter resin is useful for purposes of microscopic study or of photomicrography.

For example, a better contrast between quartz and orthoclase in an intergrowth of the two minerals is obtained in a thin section mounted in hyrax (Pl. II, Fig. 2) than in a section of the same intergrowth mounted in balsam (Pl. II, Fig. 1). Consequently, the relations between the two minerals are more clearly shown in the former. The cleavage of the feldspar and the fractures in the quartz are also more prominent in the section mounted in hyrax. In this case improvement was obtained by increasing relief.

PLATE II

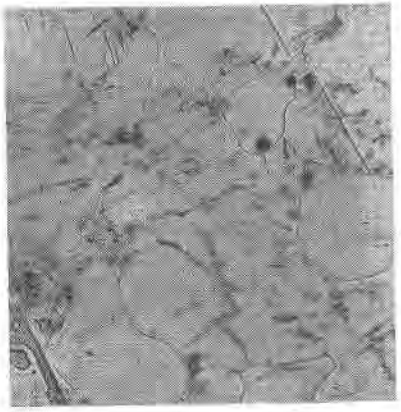

FIG. 1. Section of an intergrowth of quartz and orthoclase mounted in Canada balsam.

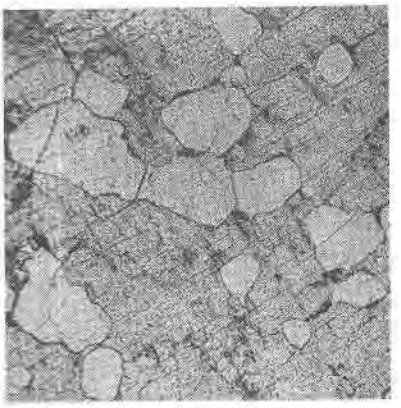

FIG. 2. Section of the same intergrowth of quartz and orthoclase, mounted in hyrax.

FIG. 3. Section of an aggregate of amphibole, mounted in Canada balsam.

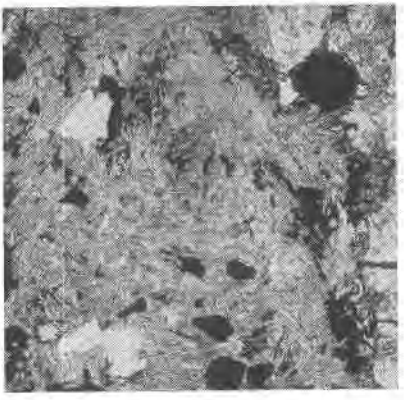

FIG. 4. Section of a similar aggregate of amphibole, mounted in hyrax.

On the other hand, certain kinds of structures are more clearly defined in thin sections when relief between the minerals concerned and the mounting material used is low. In cases of this sort in which the indices of refraction of the minerals (or mineral) involved lie closer to the index of hyrax than to the index of balsam, the

former resin is the more satisfactory mounting material. The aggregate of amphibole replacing an earlier ferromagnesian shown in Fig. 3 (section in balsam), and in Fig. 4 (section in hyrax) of Plate II is an example of this type of structure. The relief of the aggregate is too high in balsam; hence the structure is confused in the section mounted in this resin. In hyrax the relief is much less, and the details of the structure are more clearly resolved.

The applications of hyrax discussed above are not presented as an exhaustive list of its possibilities, but they serve to indicate its potential usefulness in mineralogy and petrography. Numerous other purposes for which it is satisfactory will doubtless be discovered from time to time.

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